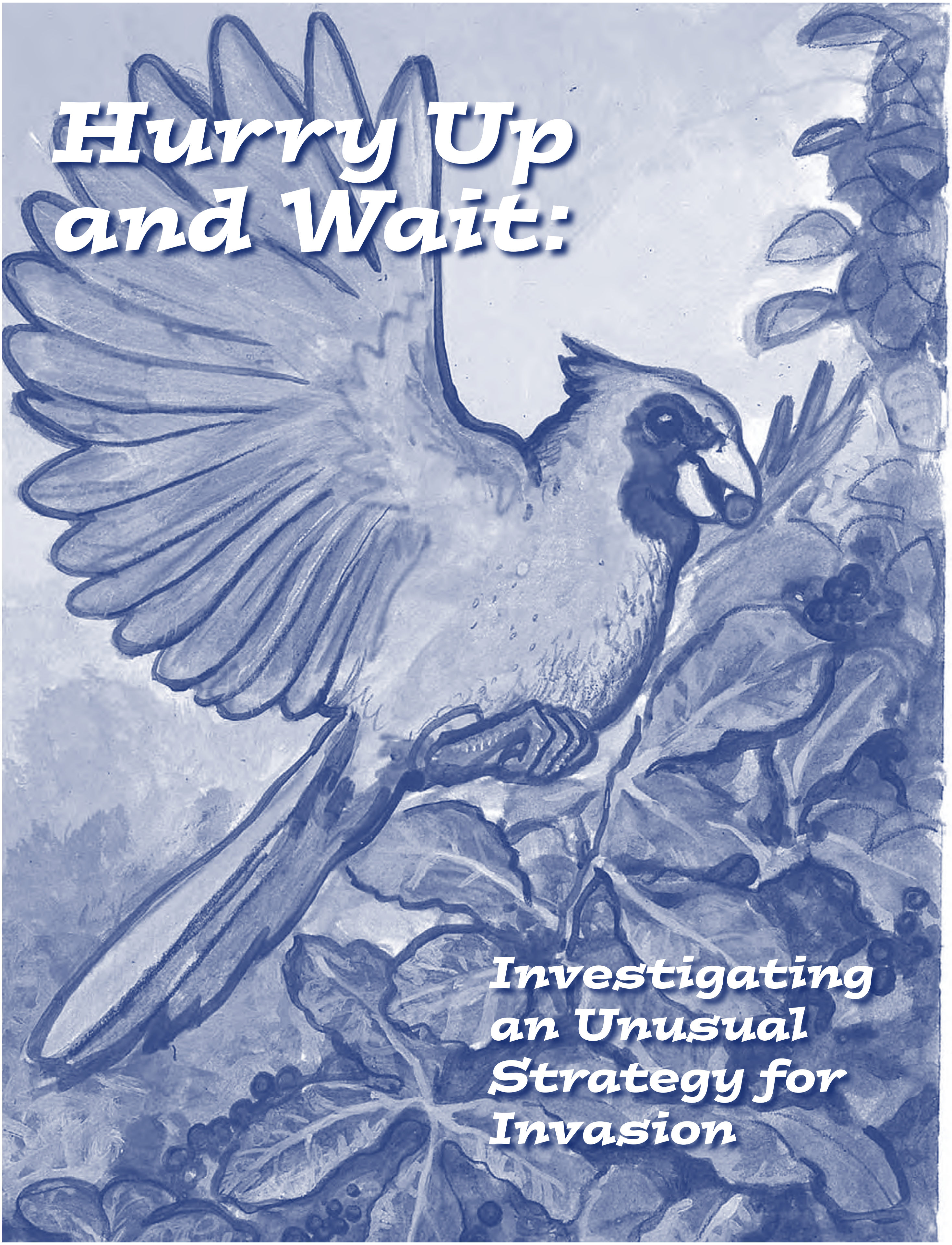
Hurry Up and Wait:

Investigating an Unusual Strategy for Invasion



Meet the Scientists

◄ **Dr. Greenberg:** My favorite science experience is learning how animals need plants for food and *habitat* and how many plants also need animals to *disperse* their seeds to new places.

Ms. Moody: ► My favorite science experience occurred when I was teaching high school. I taught Earth/environmental science and did a stream study on our campus with each class. I loved seeing the students get really excited about the bugs we were catching and getting into the data we were collecting about the health of their stream. My students always told me the stream study was one of their favorite activities of the semester.

Glossary:

habitat (**hab** uh tat): Environment where a plant or animal naturally grows and lives.

disperse (di **spürs**): To scatter or spread in all directions.

native (**na** tiv): Naturally occurring in an area.

diversity (duh **vür** suh te): The quality of being different or varied.

ecosystem (**e** ko sis tem): Community of plant and animal species interacting with one another and with the nonliving environment.

nonnative (nän **na** tiv) Not naturally occurring in an area.

defecate (**def** uh kat): To get rid of waste matter from the bowels.

resource (**re** sôrs): Something that takes care of a need.

relationship (re **la** shun ship): When two or more things are connected in some fashion.

germination (jür mi **na** shun): The act of sprouting or beginning to grow.

hypothesis (hi **paw** thuh sis): An unproven idea that is accepted for the time being and is often tested during a scientific study. Plural is hypotheses (hi **paw** thuh ses).

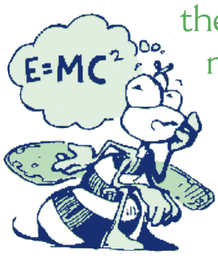
density (**den** suh ti): The condition of a substance having its parts close together.

Pronunciation Guide

a	as in ape	o	as in go	ü	as in fur
ä	as in car	ô	as in for	oo	as in tool
e	as in me	u	as in use	*ng*	as in sing
i	as in ice				

Accented syllables are in **bold.**

Thinking About Science



When scientists complete their research, they communicate the scientific method they used and their findings with other scientists by submitting a writeup of their research to a scientific journal. Other scientists evaluate the writeup and make suggestions about how the scientists can improve the writeup. The writeup may be accepted or rejected by the journal based on these evaluations.

If your teacher asks you to write a paper and then gives you feedback on how your paper can be improved, he or she is doing something similar to what scientists do. There are two major differences, however. When your teacher gives you feedback, you know who is making the suggestions for improvement. When scientists review and evaluate the writeups of other scientists, the identity of the reviewers is kept secret. This method is called a blind review. A blind review gives the reviewers more freedom to make suggestions. The other difference is that the reviewers do not know who wrote the paper they are reviewing. What is one advantage of keeping the author's identity a secret?

Thinking About the Environment

When plants are introduced into an area where they are not *native*, they sometimes reproduce to the point of disrupting or destroying the native vegetation. When this change happens, plant *diversity* is reduced and normal *ecosystem* processes are changed. *Nonnative* plants that damage a native ecosystem are called invasive plants.

Invasive plants have certain characteristics that help them invade and take over the native ecosystem. For example, they often produce lots of seeds that are dispersed far and wide by wind or animals. They can also spread by underground roots called suckers. In this study, the scientists studied a plant with some of these traits called the Oriental bittersweet (**figure 1**). Oriental is a term that used to refer to areas east of the Mediterranean Sea. The region known now as Asia, therefore, used to be called the Orient.

Figure 1. Oriental bittersweet. Photo by Henry McNab.

Introduction

The Oriental bittersweet is a vine that was transported to the United States from Asia in 1860. Oriental bittersweet is attractive, partly because it produces lots of bright orange berries (**figure 2**). Unfortunately, birds eat the berries and then fly away from the plant. When the birds *defecate*, they deposit the seeds deep in the forest, often far from where the seeds were eaten. Oriental bittersweet escaped from gardens and has spread into natural areas where it is not native. When the vine takes over natural areas, native vegetation cannot compete with it for the *resources* they need. These resources include space, water, and sunlight (**figure 3**).

Figure 2. Oriental bittersweet berries.

Figure 3. Oriental bittersweet taking over resources in an open area within a forest. Photo by Henry McNab.

Oriental bittersweet, like many invasive plants, grows well in an area with a lot of sunlight. Often, invasive plants cannot grow well in a forest. This lack of growth happens because the leaves overhead create a shade so deep that invasive plants cannot become established. Oriental bittersweet is different. It seems as if Oriental bittersweet is able to become established in deep shade. Then, it just sits and waits for an opportunity to grow.

At some time in the future, something might happen in the forest to disturb the deep shade. An old tree could fall over on a windy day, or a wildland fire could burn an area of forest. When sunlight hits the small Oriental bittersweet, it reacts by growing and reproducing quickly. Soon, Oriental bittersweet has reproduced so much that it has grown over the native plants (see figure 3).

The scientists in this study wanted to learn more about the *relationship* between different amounts of sunlight and the *germination* and growth of Oriental bittersweet. They wanted to test the *hypothesis* that the amount of sunlight reaching the ground will affect the percentage of seeds that germinate and the rate at which the seedlings grow.

Reflection Section

- What human actions caused the problem we now have with Oriental bittersweet? What actions might be taken today to help solve the problem?
- If you were the scientist, how would you set up an experiment to compare the amount of seed germination and growth under different amounts of shade and sunlight?

Method

The scientists conducted their experiments in a greenhouse (**figure 4**). The scientists planted an Oriental bittersweet seed in each of 100 identical containers using the same kind of potting soil. They divided the 100 containers into 5 groups of 20 containers in each group. They exposed each of the five groups to a different amount of sunlight (**figure 5**).

Figure 4. The greenhouse where the scientists conducted their experiments.

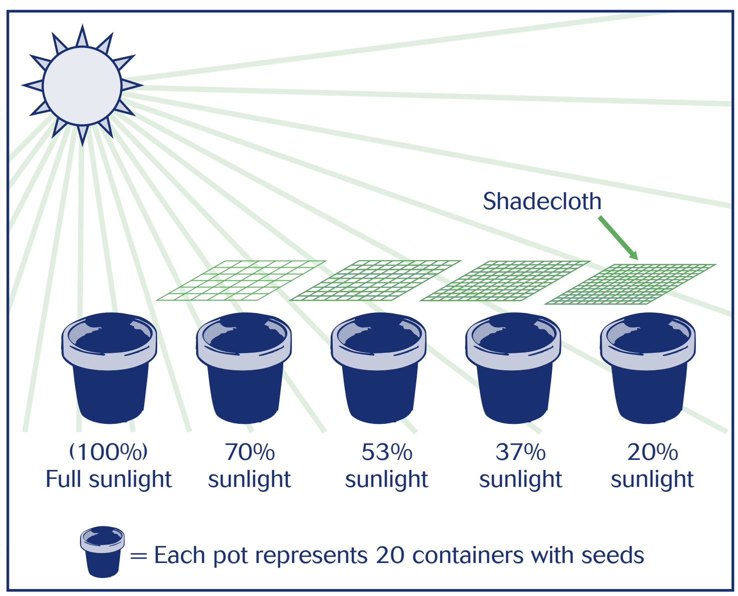


Figure 5. Each group of containers received a different percentage of sunlight by covering the containers with different densities of shadecloth.

The scientists controlled the amount of sunlight reaching each group of containers by using shadecloth. Shadecloth is like a screen but is more flexible. Shadecloth can be purchased at different *densities*. The denser the weave of the shadecloth, the less the amount of sunlight that can shine through it. The scientists used a piece of equipment called a quantum sensor (**figure 6**) to measure the amount of sunlight reaching each group of containers.

The scientists covered all but the "full sunlight" containers with increasing densities of shadecloth in the greenhouse (**figure 7**).

The scientists watered and observed the containers every day. They recorded the date of seed germination. After 100 days, they counted the number of leaves and measured the lengths of the plant stems and the roots in each container. Then they compared the germination and growth of the five groups of Oriental bittersweet vines.

Figure 7. The scientists covered the containers with shadecloth that allowed different amounts of sunlight to reach the pots. This photograph shows another experiment that is similar to the study of Oriental bittersweet, except that the pots contain oak seedlings.

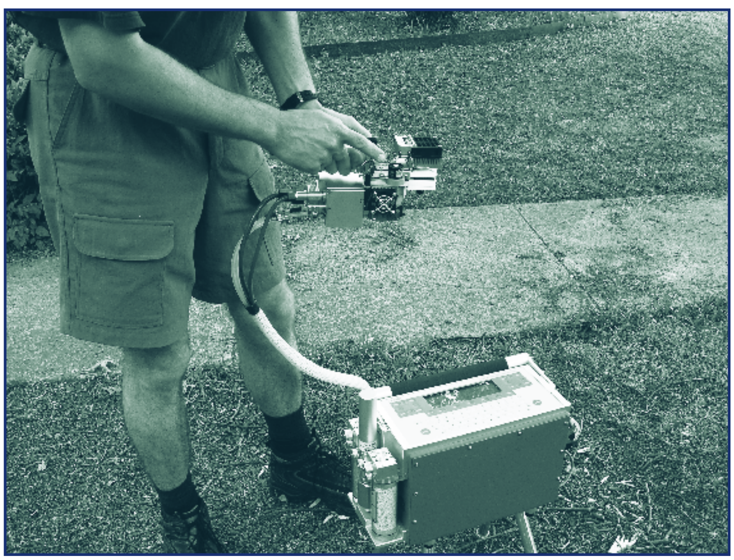


Figure 6. The scientists used a quantum sensor to measure the amount of sunlight reaching each group of containers. Here, the scientist is pointing to the part of the equipment that senses light. The box on the ground records and displays the information.

Reflection Section

- What is the reason the scientists used shadecloth to cover the four groups of containers and a quantum sensor to measure the amount of sunlight reaching them?
- Why did the scientists count the number of leaves and measure the roots and stems of each plant?

Findings

The scientists found no large differences among the different groups of containers (**table 2**). About the same percentage of seeds germinated in each group, with an average of 55 percent of the seeds germinating.

Even though the differences were not very great, the scientists found that the plants in containers with 100 percent and 70 percent sunlight grew a greater number of leaves and had longer stems and roots than the plants receiving a smaller percentage of sunlight. Look at table 2 and see if you can find the one exception to this finding.

Discussion

This study shows that Oriental bittersweet can become established under a wide range of sunlight conditions. Even in heavily shaded areas, the seeds will germinate and grow. Because of this pattern, Oriental bittersweet seeds do not need to be transported to a sunlit area to reproduce. Once the plants become established in a shaded area, they remain alive but do not grow very large. By being able to wait until something happens to open a shaded area to sunlight, Oriental bittersweet has been able to survive and spread across most of the United States. ■

Reflection Section

- Basing your answer on what you know about plant germination, does it surprise you that Oriental bittersweet germinated and grew at about the same rate, regardless of the amount of sunlight? Why or why not?
- Reread the second paragraph in the "Introduction." What do you think would happen to the plants in the five groups if the scientists had let the plants grow for another 100 days before measuring them?

Reflection Section

- Do you think Oriental bittersweet could become a bigger threat to native forests in the future? Why or why not?

From Greenberg, C., H.; Smith, L.M.; Levey, D.J. 2001. Fruit fate, seed germination, and growth of an invasive vine—an experimental test of 'sit and wait' strategy. *Biological Invasions*. 3: 363–372.

Percentage of sunlight	100	70	53	37	20
Number of leaves	19	18	13	16	13
Days until germination	16	15	13	15	14
Stem length in centimeters	8.1	8.2	7.0	8.2	7.5
Root length in centimeters	27.8	27.8	25.6	26.5	25.2

Table 2. No large differences exist among the groups of containers.

FACTivity

In this FACTivity, you will examine how different amounts of light affect another type of seed's germination. You will compare this seed's germination pattern with the germination pattern of Oriental bittersweet. You will answer the following question:

How does the amount of light affect the germination of lima bean seeds compared with the amount of light affecting the germination of Oriental bittersweet seeds?

You will use the following method to answer this question:

1. Get 16 pieces of screening, like the screening you might find on a screen door. Each piece should be about 4 inches square.
2. Get 12 lima beans from a seed store. Put potting soil in 12 plastic cups and then plant seeds about 3/4ths of an inch to 1 inch below the surface of the soil. Water the soil until it is moist. Number each cup from 1 to 12.
3. Place cups 1–4 in direct sunlight. They will receive 100 percent sunlight.
4. Cover cups 5–8 with one layer of screening. Cover cups 9–12 with four layers of screening. Cups 5–8 will receive 50 percent sunlight, and cups 9–12 will receive 10 percent sunlight.
5. Place cups 5–12 near the cups in direct sunlight.
6. Note that the screening will provide different amounts of shade for the cups.
7. Water the seeds every day and replace the coverings. Count the number of days until each seed germinates. Use the chart below to record your data.
8. After all the seeds have germinated, look for a pattern in the germination of the seeds. Is the pattern similar to or different from the pattern of Oriental bittersweet germination (from table 2 in the "Findings" section)? How is it similar or different? Now answer the question posed at the beginning of this FACTivity.
9. Continue to water the seeds for 2 weeks and record their progress. At the end of 2 weeks, measure and record the length of the stems. Compare your findings with the findings in table 2. How are your findings similar or different?
10. Basing your conclusion on the findings in the study of Oriental bittersweet, what might you conclude about the ability of lima bean seeds to survive in the same manner as Oriental bittersweet? What would you need to do to be certain of your conclusion?

Alternative Method of Seed Germination

Use three 9- by 11-inch trays. Place four to five moist (not soaked) paper towels on the bottom of each tray. Place 10–12 lima bean seeds on the paper towels in each tray. Cover the trays with plastic wrap and place them in direct sunlight. Cover one of the trays with a double layer of screening and another with four layers of screening. Keep the paper towels moist. Observe and record the germination of the seeds using a chart similar to the one shown below. This method of germination will enable students to see the seeds germinate.

Cups	Cup 1 Full sun	Cup 2 Full sun	Cup 3 Full sun	Cup 4 Full sun	Cup 5 Med. shade	Cup 6 Med. shade	Cup 7 Med. shade	Cup 8 Med. shade	Cup 9 Most shade	Cup 10 Most shade	Cup 11 Most shade	Cup 12 Most shade
Days until germination												

If you are a Project Learning Tree-trained educator, you may use PLT Pre K–8th Activity Guide #27, "Every Tree For Itself," and Activity Guide #41, "How Plants Grow," as additional activity resources. These activities teach plant growth requirements and competition for resources, and they investigate various conditions for plant growth.